

Time course of decreased lung compliance in subjects requiring permanent ventilation dependence: A prospective cohort study

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Abstract

Background: Lung compliance in patients with ventilator management affects the ventilatory status and mortality. However, there are few studies on permanent ventilation dependence (PVD) and time course studies on lung compliance have not been conducted. We aimed to clarify the longitudinal factors affecting lung compliance during the chronic period in PVD subjects.

Methods: A prospective cohort study was performed on 24 PVD subjects on ventilator management for approximately 6 years who were evaluated twice between 2019 and 2020. We compared static (Cst) and dynamic (Cdyn) lung compliance, and alveolar-arterial PO₂ difference (P(A-a)O₂) between the two measurements, and examined correlations of Cst and Cdyn over time with BMI, age, ventilator management days, and the incidence of pneumonia. Subjects were divided into two groups according to the presence of atelectasis, and Cst, Cdyn, and P(A-a)O₂ were compared.

Results: There were no significant changes in lung compliance between the two measurements in the cohort. However, at the individual level, a decrease in BMI inhibited the decrease in Cst. There was no relationship between P(A-a)O₂, age, ventilator management days, or the incidence of pneumonia and differences in Cst or Cdyn. Differences in P(A-a)O₂ were not different between the two groups divided by atelectasis.

Conclusions: Increased BMI affected lung compliance in PVD subjects during 1 year in the chronic period. Regarding atelectasis, its relationship with differences in Cst and Cdyn was not clear, and impaired lung compliance was considered to resolve after several years of PVD.

Introduction

Permanent ventilation dependence (PVD) is defined as the failure to wean the patient from the ventilator for more than 3 months. Long-term ventilator management was reported to be associated with an increased risk of pneumonia, respiratory muscle atrophy, decreased lung capacity, decreased lung compliance, and atelectasis. There are few previous studies on PVD. In a previous cross-sectional study, we evaluated Cst and dynamic lung compliance (Cdyn) in subjects with PVD, and found that a larger body mass index (BMI), ventilatory management days, alveolar-arterial oxygen difference (P(A-a)O₂), and rapid shallow breathing index are factors related to a smaller Cst and Cdyn. Furthermore, Cst may be influenced by the presence of atelectasis, age, and incidence of pneumonia. Thus, lung compliance is known to decrease in patients undergoing long-term ventilation management, but the time course has not been clarified. Therefore, we re-evaluated the lung compliance in PVD subjects approximately 1 year after the last evaluation to confirm the progressive impairment in lung compliance and the affecting factors after long-term treatment for PVD.

Methods

Subjects

The subjects were PVD subjects admitted to the ventilator center of Asanogawa General Hospital who underwent ventilator management for more than 3 months. First, Cst and Cdyn were measured in 2019, and complications of atelectasis and pneumonia, age, sex, height, weight, BMI, and ventilatory management days were collected from the records as basic information. PaO₂, PaCO₂, and FiO₂ were measured as blood biochemical findings, gas exchange capacity was assessed, and P(A-a)O₂ was calculated. Similar measurements were taken during 2020, with a minimum of 435 days, maximum of 557 days, and median of 505 days after the initial measurement. This study was conducted based on approval by the ethical review committee of Asanogawa General Hospital (approval number 174).

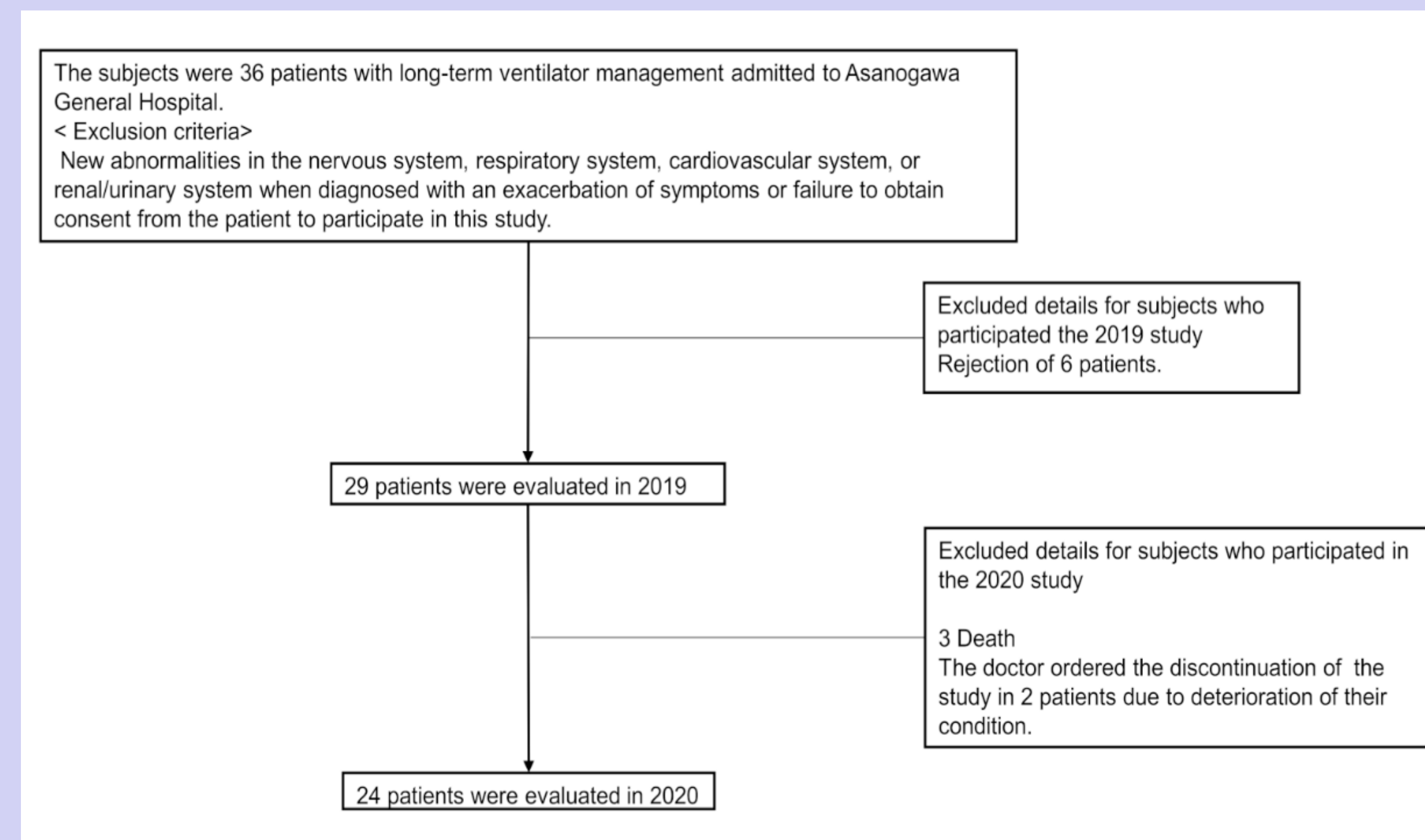


Fig. 1. Flow chart

Endpoints and measurement methods

Cst and Cdyn were measured using the end-inspiratory pause method (Fig. 2) with a Servo-s ventilator (MAQUET Critical care AB, Sweden). Before the measurement, we performed sputum suctioning and measured the cuff pressure of the tracheal tube to prevent any effects on measurement values, and we confirmed that there was no air leakage from the mouth or tracheostomy during ventilation.

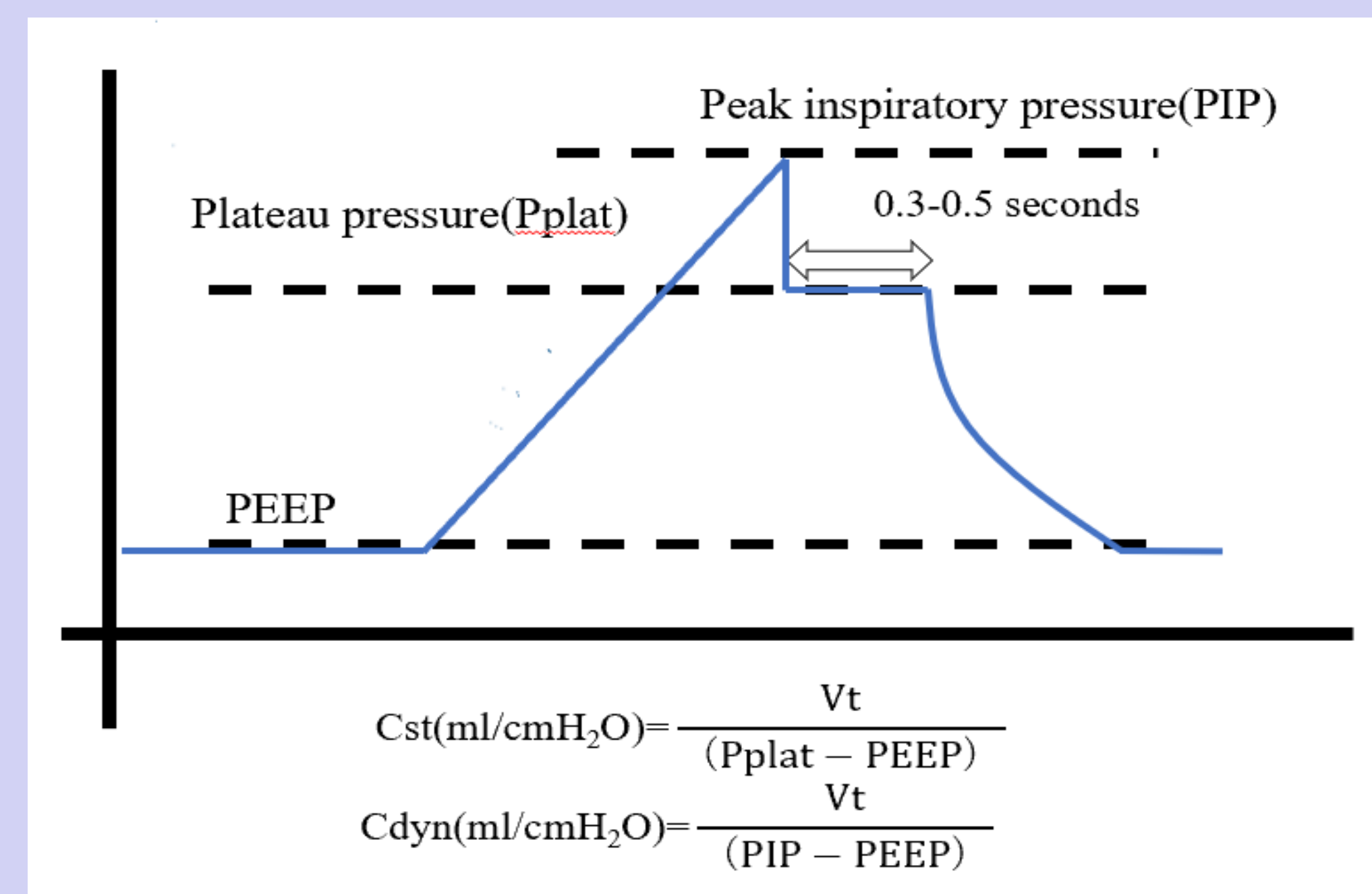


Fig. 2. end-inspiratory pause method

The presence of atelectasis was diagnosed by the same physician using chest radiography at the time of the surveys. The incidences of pneumonia in the past 1 year from the time of the survey were counted from the medical records. Pneumonia was defined as the development of clinical symptoms, such as fever, decreased ventilation, and increased sputum volume, and the physician's definitive diagnosis of pneumonia was made by chest radiography.

Statistical analysis

The differences between the two measurements of Cst, Cdyn, and P(A-a)O₂ of the 24 subjects were examined by the corresponding two-tailed t-test. Differences in lung compliance (baseline minus follow-up) were assessed for correlation with age, BMI, and differences in P(A-a)O₂ by Pearson's product rate correlation coefficient (two-sided) and correlation with the incidence of pneumonia, and the number of days of ventilator management was assessed by Spearman's rank correlation coefficient (two-tailed). Subjects were divided into two groups according to the presence of atelectasis, and corresponding t-tests (two-tailed) between the two groups were performed for lung compliance and the difference in P(A-a)O₂. The significance level was set at less than 5% and EZR (ver2.6.1) was used for all data analyses.

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Results

The characteristics of the subjects are shown in Table 1. The comparison of Cst and Cdyn between baseline and follow-up revealed no significant difference. Atelectasis was observed in 13 subjects at baseline, 4 of whom discontinued the study, and the remaining 9 subjects had atelectasis at follow-up without new atelectasis. One subject who had no atelectasis was excluded from the present study because of death. There was no difference in Cst or Cdyn (measured in 2020) between the groups in terms of atelectasis (Fig. 3). In contrast, the values of both Cst and Cdyn slightly decreased in the group without atelectasis and increased in the group with atelectasis over the course of 1 year, and significant differences were noted between the two groups in the values (Table 2). No significant differences were found in the difference in P(A-a)O₂ between groups in terms of atelectasis. A decrease in Cst was related to an increased BMI ($r=-0.41$, $p=0.047$), but P(A-a)O₂, age, ventilatory management days, and pneumonia incidence were not associated with the differences in Cst or Cdyn (Table. 3)

Table 1. Baseline and follow-up characteristics of the subjects.

| Parameters | Baseline | Follow-up | p-value |
|---|---------------|---------------|---------|
| Age | 75.38 ± 9.70 | 76.71 ± 9.66 | |
| Sex (male/female) | 10/14 | | |
| Height (cm) | 157.92 ± 8.73 | | |
| Weight (kg) | 53.00 ± 10.61 | 51.80 ± 9.45 | |
| Body mass index | 21.18 ± 3.51 | 20.73 ± 3.04 | 0.25 |
| Number of days of ventilator management | 2341 ± 1547 | 2855 ± 1529 | |
| Number of pneumonia incidences per subject | 2 (1-3) | 2 (1-3) | |
| Static lung compliance (ml/H ₂ O) | 35.88 ± 10.16 | 35.32 ± 9.34 | 0.66 |
| Dynamic lung compliance (ml/H ₂ O) | 23.14 ± 5.96 | 22.00 ± 6.01 | 0.23 |
| Alveolar-arterial oxygen difference | 21.73 ± 20.13 | 19.33 ± 21.16 | 0.58 |
| Diagnosis (n) | | | |
| Spinal cord injury | 6 | | |
| Hypoxic encephalopathy | 3 | | |
| Head trauma | 1 | | |
| Subarachnoid hemorrhage | 4 | | |
| Acute subdural hematoma | 2 | | |
| Brainstem infarction | 2 | | |
| Spinal cord infarction | 1 | | |
| Amyotrophic lateral sclerosis | 4 | | |
| Parkinson's disease | 1 | | |

Table 2. Cst, Cdyn, and P(A-a)O₂ t-test by the presence of atelectasis.

| | Atelectasis | | p-value |
|----------------------|-------------|------------|---------|
| | Presence | Absence | |
| Cst | -2.69±5.43 | 2.51±5.75 | 0.01* |
| Cdyn | -1.63±3.52 | 2.81±4.28 | 0.03* |
| P(A-a)O ₂ | 2.57±26.28 | 2.31±18.95 | 0.98 |

Data are calculated values of baseline minus follow-up.

*p<0.05

Table 3. Correlation coefficients for each item with differences in Cst and Cdyn.

| | Cst | | | Cdyn | | |
|--|-------------------------|------------------|---------|-------------------------|-----------------|---------|
| | Correlation coefficient | 95% CI | p-value | Correlation coefficient | 95% CI | p-value |
| BMI | -0.41 | (-0.69 to -0.01) | 0.047* | -0.38 | (-0.68 to 0.03) | 0.07 |
| P(A-a)O ₂ | 0.32 | (-0.09 to 0.64) | 0.12 | 0.34 | (-0.08 to 0.65) | 0.10 |
| Age | 0.17 | (-0.25 to 0.53) | 0.43 | 0.26 | (-0.16 to 0.60) | 0.20 |
| Number of days of ventilator management | -0.14 | (-0.52 to 0.28) | 0.51 | -0.33 | (-0.65 to 0.09) | 0.12 |
| Number of pneumonia incidences per subject | 0.09 | (-0.32 to 0.48) | 0.66 | 0.23 | (-0.19 to 0.58) | 0.27 |

*p<0.05

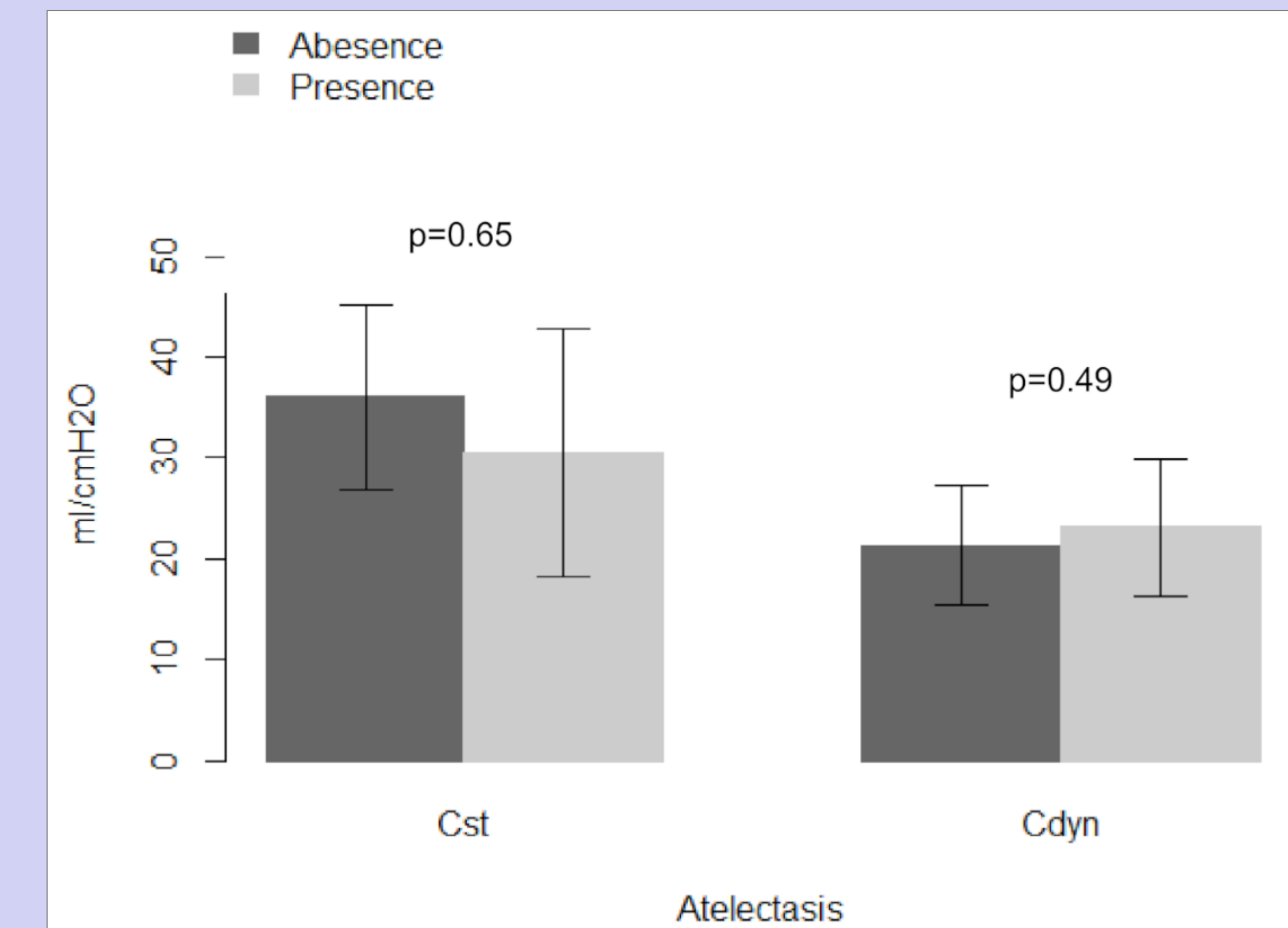


Fig. 3. Comparison of lung compliance (measured in 2020) between groups by the presence of atelectasis.

Conclusion

Ventilator management is considered to reduce lung compliance, but no progressive influence was observed after long-term management of approximately 6 years in subjects with PVD. The results suggest that lung compliance changes significantly in the early stages of ventilator introduction and thereafter shows a degree of fluctuation depending on individual differences such as BMI. The relationship between atelectasis and the difference in lung compliance was unable to be clarified. A longer observation of atelectasis, and the severity of pneumonia and other lesions must be considered to identify factors related to the changes in lung compliance.

Limitations

This study are that we were unable to ethically adopt this study method for subjects whose condition deteriorated; therefore, we limited our study to subjects with stable symptoms. As this was a study at a single institution with long-term hospitalization, the number of subjects was small. Furthermore, the follow-up period was only 1 year and long-term changes were not sufficiently confirmed. All subjects in the study had a neurological diagnosis. As neurological respiratory impairment requires prolonged ventilation by a different mechanism than primary lung disease, changes in compliance levels over time may be different in subjects with chronic respiratory failure without primary lung disease.

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Disclosures

*The authors declare no conflicts of interest associated with this manuscript.

*The authors have no conflicts of interest directly relevant to the content of this article.



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